Collapsible Larval Fish Light Trap Using Low-power LED Light Source

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Abstract--*Light traps have been shown to be valuable in the conservation and monitoring of endemic desert fishes. To use this method sampling in Rio San Bernardino, Sonora, Mexico, a trap was developed that is of a robust, power-efficient design. This trap disassembles and nests into itself for safe storage and transport and can be easily assembled in the field without tools. Using two lithium coin cells as a power source, light from a light emitting diode is diffused by the translucent high-density polyethylene quatrefoil trap body. Initial field tests indicate this to be an effective design and a possible alternative to more typical quatrefoil light traps of acrylic or polycarbonate construction.*

INTRODUCTION

The sampling and monitoring of larval and juvenile fishes has been shown to be an effective indicator of abundance and survival and an aid in better understanding a population's structure, as early life stages are often underrepresented using other sampling methods such as electrofishing or seine netting (Murphy and Willis 1996). By analyzing data from early life stages trends in population structure are more rapidly apparent. These methods are widely used in both inland and marine fisheries, and numerous projects have focused specifically on endemic desert fishes. In addition to serving as a tool for population data collection, captured larva of imperiled desert species have been reared under protection and released at significantly larger size as part of ongoing conservation efforts (Marsh et al. 2005).

The use of the light trap as a sampling method takes advantage of the positive phototactic behavior observed in many species of fishes and other organisms. This behavior, where organisms orient themselves and move toward light, likely serves as a response to avoid potential danger or move to more favorable conditions (Barton 2007). Positive phototaxis has been experimentally demonstrated in razorback sucker (Snyder and Meismer 1997) and bonytail chub (Massure et al. 2015). The behavior is believed to be present in other desert fish species (Massure et al. 2015; Minckley et al. 2003; Snyder and Meismer 1997). To evaluate whether this behavior may be present in Yaqui chub (*Gila purpurea*), and as part of ongoing monitoring in the Rio San Bernardino of Sonora, Mexico (Figure 1), the light trap discussed in this paper was developed.

DESIGN

Various designs of light traps have been used to sample phototactic fish larvae. One common design used in inland waters is the quatrefoil light trap, initially designed by Floyd et al. (1984). This trap features four three-quarter sections of acrylic cylinders arranged in a circular array around a central light source. Larval fish, attracted by either a chemical light stick or a waterproof battery powered lamp, enter through narrow gaps between the acrylic cylinders. These cylinders are typically bonded to a top and bottom plate. Foam floats are affixed to the top plate and the light traps may or may not include a collection pan attached to the bottom plate. (Killgore 1994; Secor et al. 1992).

The design described herein is a variation of that original configuration (Figure 2). The primary departure from previous designs is the use of high-density polyethylene tube in place of acrylic. By utilizing this durable material, the overall cost per trap was reduced and the construction process simplified. Use of this translucent material gave the added benefit of significantly diffusing light emitted by the attracting light source.

Another modification is the use of inexpensive commercially available waterproof LED modules as the primary light source. Previous efforts have made effective use of LED lighting as the attractant for light traps, however, these light sources have been specially constructed (Gyekis et al. 2006). Intended for decorative use, the compact modules used in this design are sold as submersible LED tea lights and are available in a wide variety of colors (Figure 3). These inexpensive modules are powered by two CR2032 lithium coin cells and have a run time of over 12 hours of continuous operation before a battery change is required.

Figure 1. Light traps in use in Rio San Bernardino, Sonora, Mexico (Photo by A. Livingstone, Oregon State University)

Figure 2. Light traps shown assembled for use and collapsed for transport - lid removed to show nesting of components Photo by A. Livingstone, Oregon State University)

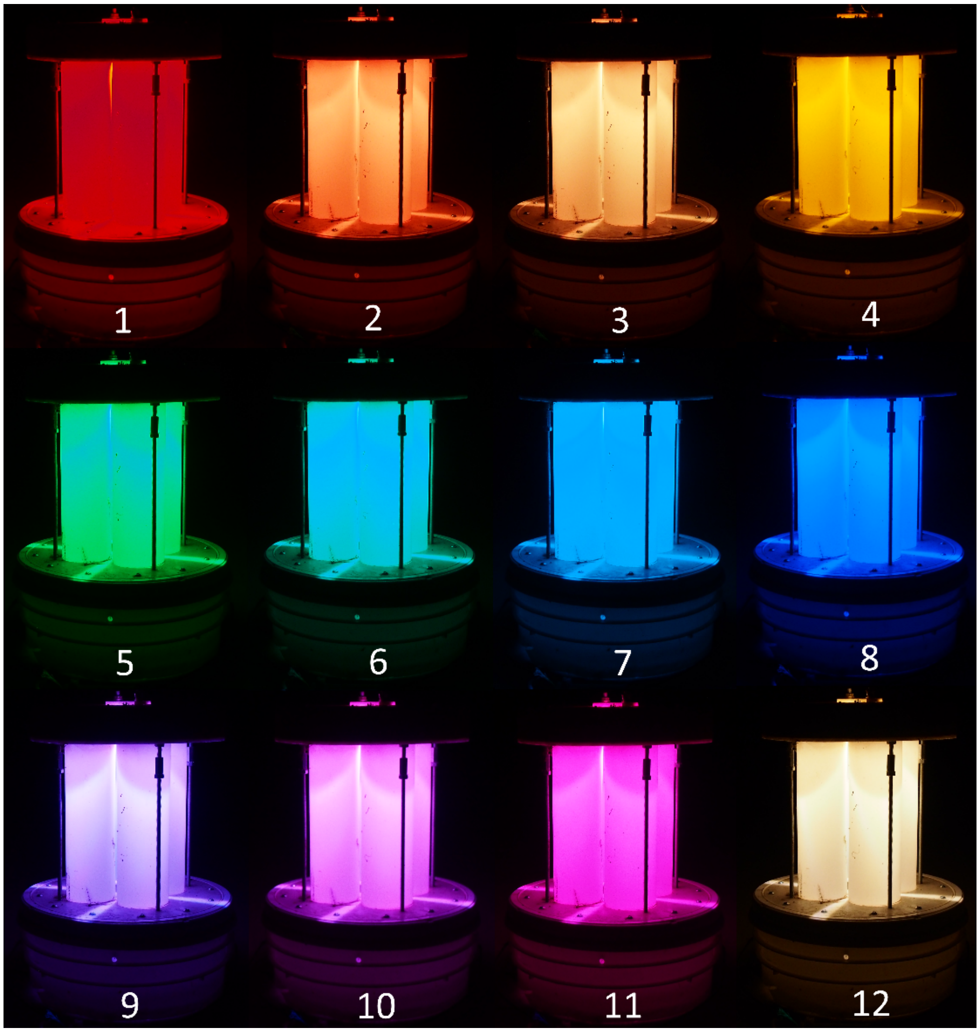

Figure 3. Selection of LED light module colors available – colors 4, 5, 12 were used in Rio San Bernardino tests (Photos by A. Livingstone, Oregon State University)

Additional modifications allow for simplified construction and compact storage. By cutting the top and bottom plates with grooves for the alignment of the cylinders these traps can be easily assembled in the field. The cylinders that make up the trap body are stored within the collection pan for transport. The collection pans are constructed from easily sourced materials. These components include generic 5-gallon (20 L) pails, screw top lids, and bucket strainers commonly available at home improvement stores or from online retailers.

MATERIALS AND METHODS

Much of the fabrication of components to build these traps was performed using a Thermwood Model C67 CNC router. This specific method of fabrication is not critical, and components could be cut using far more commonly available equipment. By carefully creating fixtures and guides, the machined components described could be recreated with a jigsaw and handheld router. The materials sourced were used because of availability as scrap from industrial manufacturing. These materials are available commercially; however, it is the author's opinion that a wide variety of materials with similar properties could be suitably substituted. Material choice for the plates used in making the traps is not critical if machinability and water resistance are considered. For the tubes that make up the trap body, translucent properties are the primary consideration.

The HDPE tubes used for the body of the trap were sourced as scrap. The original intended purpose was as the core tube supplied with rolls of adhesive backed PTFE sheeting. Tubes as sourced were 3.3 in (84 mm) OD and 36 in (914 mm) in length. When the initial cut to remove the quarter-section was made the tubes contracted to an outer diameter of 2.9 in (72.6 mm). Cutting these tubes was found to be most effectively done on the table saw, and fixtures were fabricated for alignment and to index the tube while cutting (Figure 4). After the cuts were made to remove the quarter section, sourced tubes were cut to a final length of 8.9 in (226 mm). Sharp edges were deburred and finished with 400 grit sandpaper.

The cover, top, and bottom plates (Figures 5, 6, and 7, respectively) were machined from 0.18 in (4.5 mm) thick HDPE sheet. These were also obtained as scrap, having originally served as tops and bottoms to 15-gal (56 L) fiber drums. The float was made from 1.5 in (38 mm) extruded polystyrene foam sheet. Using the CAD models designed in SolidWorks, cut paths and cut files were generated in Surfcam. The parts were then cut on a Thermwood C67 5-axis CNC router. After removal, edges of the HDPE parts were deburred and finished with 400 grit sandpaper.

The collection pan was constructed from roughly the upper 4 in (~100 mm) of a 5-gal (20 L) bucket, a modified Gamma Seal Lid, 100-micron EZ-strainer insert, and a section of 1/4 in (6.35 mm) hardware cloth. The 5-gal (20 L) bucket was marked around its circumference and then cut to size. Trial units were initially made by cutting with a razor blade. Despite having a superior cut quality, this method was quickly abandoned in favor of the use of a jigsaw, due to difficulty and safety concerns. To provide protection for the nylon mesh of the strainer, the section of 1/4 in hardware cloth was formed to fit on the inside of the new bottom opening of the section of bucket and fixed in place using high strength hot melt adhesive. A 0.4 in (10 mm) hole was drilled in the bucket section 1.125 in (28.5 mm) below the top to allow for air to escape when the trap is placed in the water. The bucket strainer was then set in the top of the bucket section and sandwiched in place by the adapter for the Gamma Seal Lid, which had the inner gasket removed. To provide a smooth surface and to prevent any fish from getting stuck while the collection pan is emptied, a bead of silicone was run around the inner surface where the Gamma Seal adapter and strainer meet. The Gamma Seal Lid was modified by cutting out the inner portion, and removing the gasket, leaving a male threaded ring with lip. The bottom plate was then set in the recessed upper surface of this ring with the grooves facing away from the threaded portion. By then rotating the bottom plate, the holes were aligned to fall between the gussets found on the underside of the ring. Using a number 7 drill bit (0.201 in, 5.1 mm) in a hand drill, the holes were then match drilled through the threaded ring. The 10-32 hardware was inserted through both components and the nuts were tightened.

The primary components of the float assembly were the cover plate, float, and top plate. Starting with the cover plate, the two 1/4-20 x ¾ in bolts were inserted through the pair of inner ¼ in (6.35 mm) holes. These were affixed in place by a spot of hot melt adhesive on each head. For added protection, the perimeter of the foam float was wrapped with a strip of 2 in (50.8 mm) yellow vinyl tape and the excess was folded over. The cover plate, with the threaded portions of hardware positioned away, was placed on one side of the float. On the other side, the top plate was positioned with the grooves facing out. The four outer ¼ in (6.35 mm) holes were aligned between the three components and the 1/4-20 x 2 in bolts were inserted. Four 1/4-20 in nuts were threaded on and tightened. The LED module of the appropriate color was then affixed to the LED module mount plate using high strength hot melt adhesive. This was then set in place over the studs extending from the cover plate and held in place by two 1/4-20 in wing nuts.

To assemble the trap for use, the HDPE tube sections are placed in the grooves on the base plate assembly. Coupling nuts are threaded to half their depth on four 1/4-20 threaded rods (8 in/203 mm long) and held in place by jam nuts. The threaded rods are then inserted through the ¼ in (6.35 mm) holes in the base plate. The float assembly is then placed on top of the tube sections, which are then aligned to the channels in the top plate. The threaded rods then are attached to the threads extending past the nuts holding the float assembly together. Nuts are then threaded onto the threaded rods from the underside of the baseplate and hand tightened. This entire assembly is then threaded into the collection pan. When the trap is being deployed the upper wingnuts are loosened and the LED module mount twisted and removed. The module is then activated and replaced.

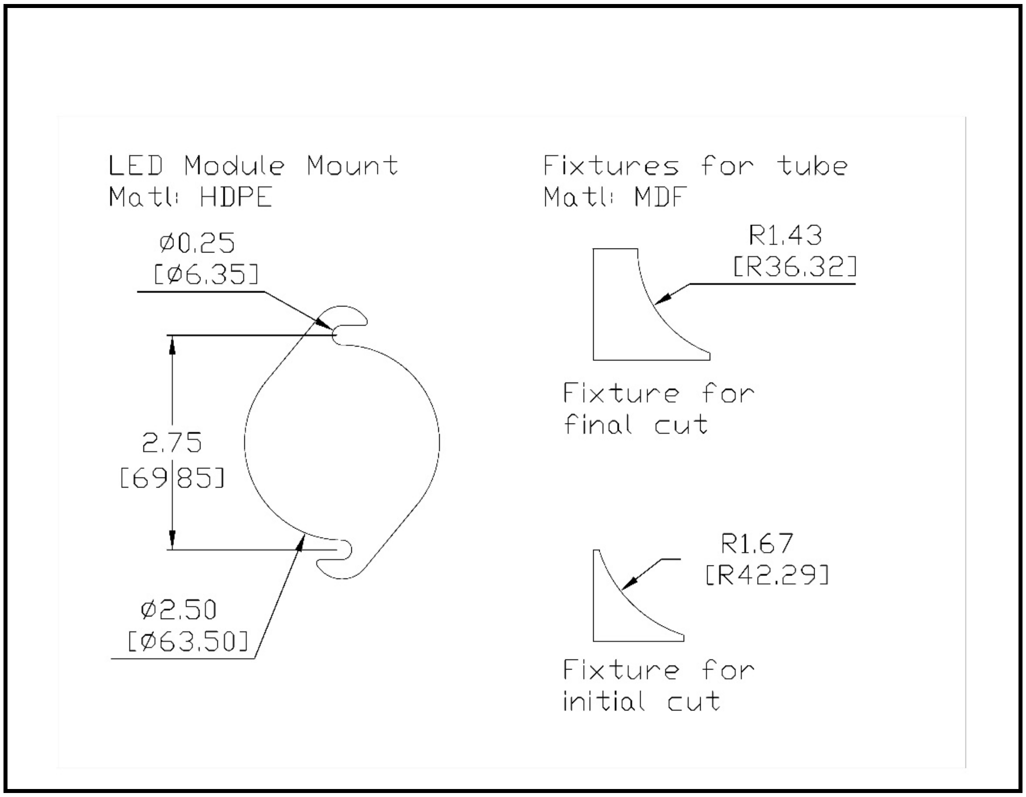

Figure 4. LED light module mount; Fixtures for indexing of tube section cuts. Dimensions: Inches [mm]

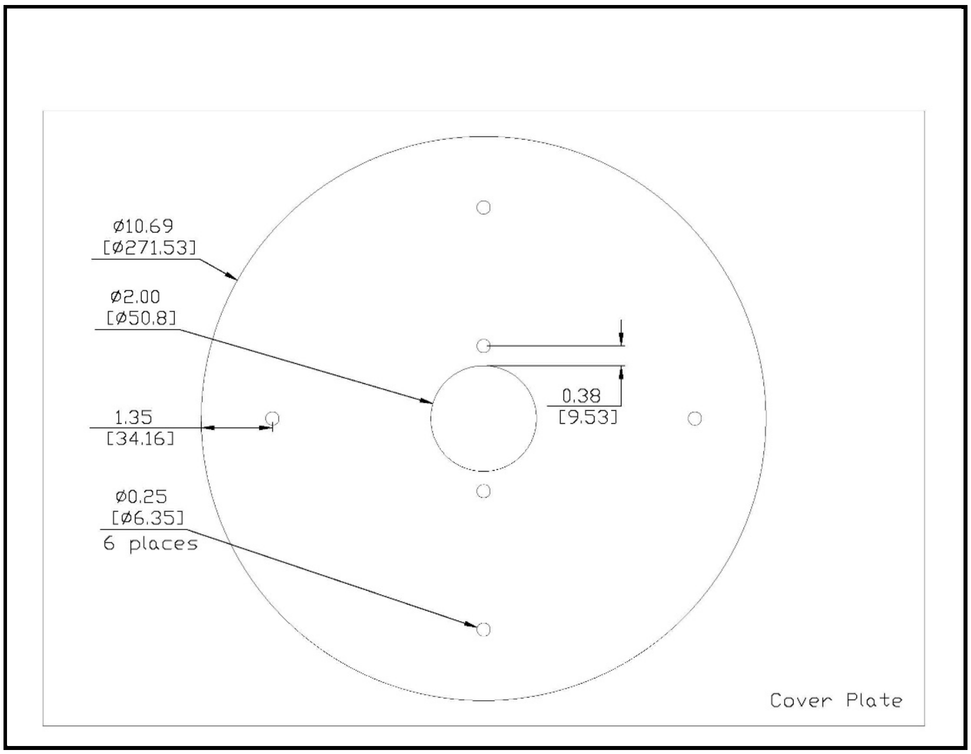

Figure 5. Light trap cover plate – material: 0.18 [4.5] HDPE. Dimensions: Inches [mm]

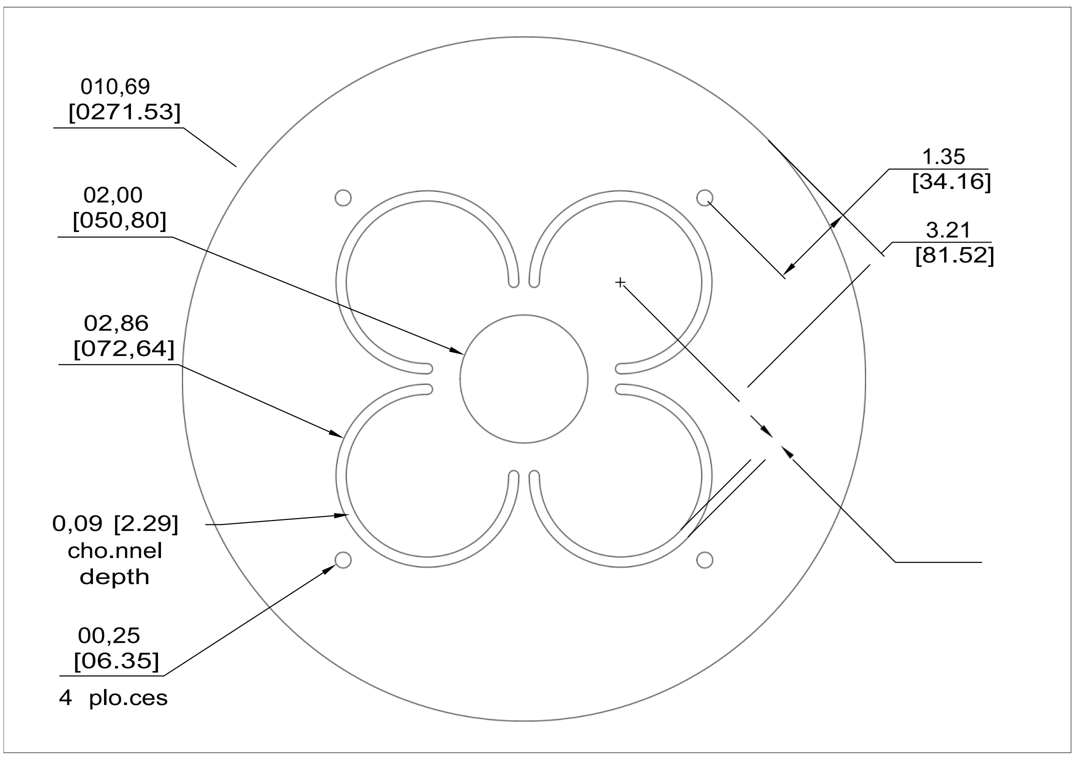

Figure 6. Light trap top plate – material: 0.18 [4.5] HDPE. Dimensions: Inches [mm]

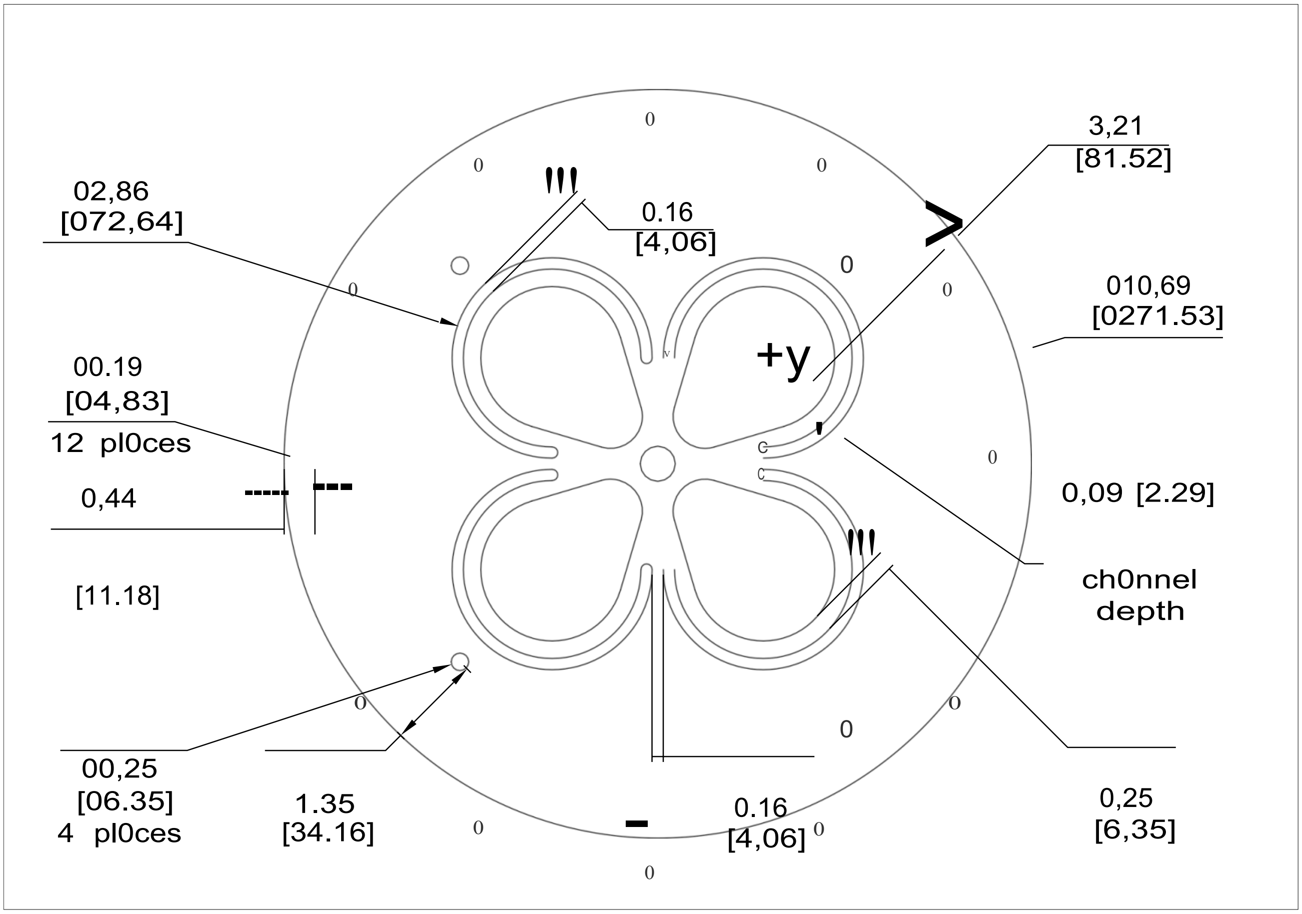

Figure 7. Light trap bottom plate – material: 0.18 [4.5] HDPE. Dimensions: Inches [mm]

For disassembly and storage, the upper assembly is removed from the collection pan. The nuts holding the threaded rods to the base plate are removed and the sections are separated. After removing the threaded rods and coupling nuts from the float assembly, the float assembly is placed on the base plate, aligning the extending bolt threads with the 1/4" (6.35 mm) holes in the base. The nuts are then threaded on and hand tightened from the underside. The threaded rod/coupling nut assemblies and tube sections are then placed in the collection pan and the base plate with attached float assembly is threaded on (Figure 2).

DISCUSSION

At the time of writing no larval fish have been captured using this trap design. In addition, the opportunity to use the trap in a controlled environment and verify its effectiveness with phototactic larval fishes has not yet been available. However, the use of this trap in the Rio San Bernardino has yielded mixed catches of poeciliids (Yaqui topminnow and mosquitofish) and aquatic invertebrates representing several orders (including Odonata, Diptera, and Coleoptera). These sampling efforts have been limited but have co-occurred with other sampling methods (seining and minnow traps). In this same time frame no larval or juvenile Yaqui chub have been captured using any of the methods tried. During initial sampling water conditions were likely out of the range of Yaqui chub spawning conditions (Kline and Bonar 2009) and traps were set to test physical performance characteristics (light intensity and duration, flotation, etc.). Only two sampling events were within possible Yaqui chub spawning conditions. Further sampling efforts will be necessary to observe the possibility of this behavior in Yaqui chub. However, based on performance of capture of non-target species, it is believed that the design is likely to be effective with phototactic larvae.

Additional modifications and alterations are under consideration. Variation of the color of light used as an attractant is one such option. In experiments performed by Gehrke (1994), it is suggested that the color of light used can be optimized for the target species and present water conditions. For the sampling events in the Rio San Bernardino, three different colors have been used – white, yellow, and green (Figure 3). However, initial results between these appear to have been similar. An additional concern that may affect capture rates of larval fishes is predation by poeciliids. Based on results of testing performed by Vilizzi et al. (2008), the addition of an outer mesh may increase trap rate by excluding poeciliids which potentially prey on captured larvae.

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